The daylight saving time anomaly in relation to firms targeted for mergers

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Abstract

This paper finds evidence that daylight saving time changes influence the decision-making of investors when trading in firms targeted for mergers. We find that investors who face imbalances in their circadian cycle generate more positive abnormal stock returns upon the announcement of target firms. This result holds within a large number of robustness tests. Target firms also experience more pronounced stock return volatility in response to their merger announcements the first trading day after clock changes. Overall, these results seem to indicate that investors may overreact to available information when experiencing imbalances in their circadian cycle.

JEL classification: G11; G12

Keywords: Daylight Saving Time Changes; Circadian Cycle; Merger and Acquisition; Target Firms; Stock Price Efficiency

1. Introduction

Sleep influences humans through a number of neurobiological processes (e.g., Achermann, 2004). The interaction of the circadian and the homeostatic processes undertaken by neural systems in the brainstem and basal forebrain determines the sleep/wake pattern. Dinges (1995), Alhola and Polo-Kantola (2007), Banks and Dinges (2007), and Walker (2017) offer comprehensive reviews indicating that there is a negative influence of sleepiness on participants' mood swings, attention, memory, and performance. A few studies (e.g., Kamstra et al., 2000; Pinegar, 2002) within the field of finance proxy sleep disturbances based on daylight saving time changes and explore whether investor decisions differ in relation to their sleep disturbances at a market level. However, as discussed in further detail below, existing empirical results are mixed. In this study, we use target firms in the context of firm mergers in order to contribute to the daylight saving time change anomaly. We offer empirical validity on the significance of daylight saving time changes in relation to investor reaction to the merger announcements of target firms.

Relatively few published studies have explored the significance of sleep in the field of finance by using the daylight saving time changes to proxy sleep disturbances. Investors are likely to experience sleep imbalances during the particular weekends that daylight saving time changes occur, and their transactions are thus expected to be influenced by sleepiness on Mondays following a time change. All participants within a country are vulnerable to the clock change; thus, a significant proportion of the population will exhibit sleep disturbances. Beyond the field of finance, a number of other studies have also used daylight saving time changes in order to explore the significance of sleep on human decisions. Smith (2016) and Robb and Barnes (2018), for example, report that more car accidents take place on the day following daylight saving time changes, mostly attributed to sleep imbalances. Also, Cho et al. (2017)

find evidence that judges give longer sentences on Mondays following daylight saving time changes in relation to other Mondays.

However, existing empirical results on the relation between daylight saving time changes and stock market returns are mixed. Kamstra et al. (2000) offer the first empirical results in this field. They use both fall and spring daylight saving time changes in order to capture imbalances in investors' circadian cycles and show that stock market returns on Mondays are relatively poor following weekends with daylight saving time changes. There has, though, been some debate between Pinegar (2002) and Kamstra et al. (2002) on the robustness of this empirical relation. Pinegar (2002, p. 1257) argues that the empirical relation is driven by two outliers linked with stock market crises. Gregory-Allen et al. (2010) further report that daylight saving time changes are not related with stock market returns in an updated international sample. Berument et al. (2010) explore whether daylight saving time changes are related with stock market returns and with stock market volatility. They follow an EGARCH model with 15 lags and find no relations. Kamstra et al. (2010, 2013), though, criticize the selection of over-parameterized models followed by Berument et al. (2010) and Berument and Dogan (2011). They instead report that daylight saving time changes are still related negatively with stock market returns in the sample used in their initial study (1967-1997) with the use of both OLS and maximum likelihood estimations.

Based on the extensive evidence in the sleep literature, it is clear that sleep matters in our decision making. There is no reason to believe that investors are an exception to this rule. In this study, we focus on offering some empirical validity of the significant impact of sleep patterns on investor decisions. Based on the sleep literature (e.g., Dinges, 1995; Alhola and Polo-Kantola, 2007; Banks and Dinges, 2007; Walker, 2017), we expect that the quality of investors' decisions is relatively poor when they experience imbalances in their sleep cycles. Human decisions are suboptimal when we lack sleep, since we tend to lack attention to detail,

as well as the required level of concentration. There is also plenty of evidence that investors have relatively stronger mood swings when experiencing imbalances in their circadian cycle (e.g., Womack et al., 2013), and it is thus more likely that investors may overreact to available information.

Our study deviates from the previous literature in the field of finance by using the extreme context of target firms in order to test whether sleep imbalances matter. Mergers are typically unexpected events, as indicated by the significant stock return reactions to their announcements. Target firms experience on average returns of 10% on their announcements (e.g., Jarrell and Poulsen, 1989; Pound and Zeckhauser, 1990; King, 2009). If investors are influenced by sleep imbalances, a relation should be evidenced, if at all, within target firms simply due to the extreme stock returns that they experience.

Target firms tend to experience the most pronounced positive abnormal stock returns on merger deals announced on Mondays due to the high investor attention on Mondays in relation to other days of the week (e.g., Louis and Sun, 2010). As shown in Table 1, we indeed find in our sample that targets announced on weekend & Mondays tend to experience the most pronounced positive abnormal stock returns. In particular the average abnormal stock returns for targets announced over the weekend and on Mondays are 11.98%, while the counterpart stock returns on other days are less than 11%. The difference in abnormal stock returns between weekend & Monday versus other days is 1.41%, which is economically significant and statistically significant at the 1% level. As stated above it is likely that investors who experience imbalances in their circadian cycle to overreact to available information. Such investors may

then push targets' stock returns to more extreme levels and thus to stronger stock returns in the announcement of such a positive firm event.[1]

[Please insert Table 1 around here]

We use US target firms as part of the mergers announced between 1977 and 2017 and find that daylight saving time changes are indeed related with investor reaction to their announcements. We find that target firms experience 2.66% stronger abnormal stock returns upon their announcement day on Mondays following clock changes in relation to other target firms after relevant controls. We find that this result holds within a large number of robustness tests. There is no relation when testing the significance of US daylight saving time changes on the stock returns of target firms in countries around the world that experience no daylight saving time changes. We further find that target firms experience more pronounced stock returns on their merger announcements on Mondays following daylight saving time changes in relation to the announcement of other targets. Overall, these results highlight the significance of sleep deprivation on investor decisions.

[1] Note that the sign of the relation between sleepiness and stock returns differs in our context in relation to previous literature. Kamstra et al. (2000) report that stock market returns are lower on Mondays following daylight saving time changes. Although it is difficult to reconcile the empirical results with direct evidence, the context of this study differs significantly from the stock market index explored by Kamstra et al. (2000). According to the Monday effect (e.g., French, 1980), stock market returns tend to be less pronounced on Mondays in relation to other days of the week. As discussed in the text above target firms tend instead to experience strong returns on their announcement on Mondays due to high investor attention in the particular day (e.g., Louis and Sun, 2010). To the extent that investors who experience imbalances in their circadian cycle tend to overreact to available information, they may thus generate relatively low stock market returns on Mondays after clock changes and relatively high targets' stock returns on Mondays after clock changes reflecting the opposite signed information available.

We contribute to the finance literature by empirically validate the significance of daylight saving time changes in the extreme context of target firms. This result is important considering that previous published papers (e.g., Kamstra et al., 2000; Pinegar, 2002; Gregory-Allen et al., 2010; Berument et al., 2010) show mixed results on the relation between daylight saving time changes and stock market returns, and no relation between daylight saving time changes and stock market volatility. Even though we use mergers as the context of our analysis, our contribution is to a less extent towards this field, mostly because daylight saving time changes occur only twice a year. Our results are of general interest to the finance community. We report that investors seem to interpret new information differently in line with their sleep patterns, which is an issue related with the stock price efficiency debate. Variability of stock returns is also a key variable in finance, such as in risk management, in predicting volatility and in asset pricing. This study shows evidence that the imbalance of investors' circadian cycles can influence targets' stock returns and their variability beyond changes in fundamentals.

The remainder of the paper is structured as follows. Section 2 discusses data and methodology. Section 3 presents the empirical results. Finally, Section 4 concludes this study.

2. Data and methodology

2.1 Data

We access US domestic mergers and acquisitions from SDC Thomson OneBanker. We collect merger deals from 1977, which is the earliest available, until November 2017. We explore public-to-public merger deals of completed merger announcements, with at least 50% acquisition. We also restrict our sample to merger deals where available targets' relative size as measured by their market capitalization in relation to that of bidders is at least 1%. We also

exclude merger deals classified as minority stake purchases, acquisitions of remaining interest, spinoffs, recapitalizations, and repurchases. These restrictions are commonly used in merger literature (e.g., Moeller et al., 2004; Agrawal and Nasser, 2012). As discussed in the introduction, we focus our analysis on target firms, since they exhibit very pronounced stock performances upon their merger announcements. Our final sample comprises 5,713 target firms out of which 90 are announced on Mondays or over the weekend following US daylight saving time changes and 5623 on the remaining days.

We collect from SDC Thomson OneBanker data on whether there was a rumor prior to each merger announcement; the SIC industry code for both targets and bidders; whether there was blockholder activity at the time of the merger announcement; whether the merger deal was tender, competitive, or hostile; and whether the pooling of interest method or the purchase method was used. We also collect from SDC Thomson OneBanker the method of payment (e.g., stock or cash and the relevant percentage), and targets' Datastream codes. We use the Datastream codes to access from Datastream the following data for targets: daily stock returns, daily stock prices, daily market capitalization (in millions), and the number of analysts following each firm.[2] The timing of relevant data collection is one day before each merger announcement. We estimate abnormal stock returns of target firms in excess of the corresponding stock market returns on the same day.[3] We winsorize abnormal stock returns of targets' firms at the top and bottom 1% (in total 2%) for main analysis in order to ensure that

[2] Due to the large amount of missing data (51% in our sample), we record the number of analysts as zero if data are not available. It is likely that relatively small firms have very few, if any, analysts following them. In untabulated results, we find that our conclusions are the same when excluding the number of analysts from the analysis.

[3] We estimate logarithmic stock returns.

our results are not driven by few observations (Pinegar, 2002). We also download targets' trading volume, which is estimated as their daily volume divided by the number of outstanding shares. All values are measured in $.

According to our data, and as an example, Gilead Sciences Inc. acquired 100% of Kite Pharma Inc. on 28 August 2017. The relative size of the acquisition was 0.8, thirteen analysts followed Kite Pharma Inc., and there was a rumor available that the deal was likely to take place. In response to this, Kite Pharma's abnormal stock returns experienced a significant run-up before its merger announcement, equal to 30%. Kite Pharma's abnormal stock returns gained a further 25% on the day of its merger announcement.

In line with the sleep literature developed in finance (e.g., Kamstra et al., 2000; Pinegar, 2002), we use daylight saving time changes to proxy investor sleepiness. Investors are likely to experience sleep disturbances during those particular weekends, and their transactions are thus expected to be influenced by sleepiness on Mondays following the time change. Daylight saving time mostly takes place in the US on the second Sunday in March and the first Sunday in November. We collect the exact dates of US daylight saving time changes from Wikipedia.[4]

2.2 Methodology

Our dependent variable for our main analysis is the abnormal stock returns of target firms on their merger announcement day, day 0. The few mergers that are announced over the weekend (less than 2% of the total number of merger deals in our sample) are grouped with Monday merger announcements, since Monday is the day that investors would first react to the new information. Our main independent variable is a dummy that takes the value of one for merger

[4] https://en.wikipedia.org/wiki/History_of_time_in_the_United_States.

deals announced over the weekend or on Mondays following daylight saving time, and zero otherwise. We follow the conventional approach within the literature (e.g., Kamstra et al., 2000) by including both fall and spring clock changes when measuring daylight saving time changes. The argument developed in the literature is that both time changes influence investors' circadian cycles and thus both should influence investor decisions. In untabulated results we indeed support empirically this conjecture by finding that both parameter coefficients during fall and spring clock changes are significantly positive.

We control for a number of variables that may influence the magnitude of the abnormal target stock returns on targets' announcements. We first control for rumors, since they are an important determinant of the announcement effect for target firms (e.g., Jarrell and Poulsen, 1989; Pound and Zeckhauser, 1990; King, 2009). When a rumor is available prior to a merger announcement, investors manage to predict the merger and thus buy stocks of forthcoming target firms. There is thus an increase in stock returns of targets with rumors prior to their merger announcements, and a relatively less pronounced increase is experienced on their merger announcement day. The rumors are collected from SDC Thomson OneBanker and are available as a dummy variable that takes one for merger deals with rumors, and zero otherwise. To ensure that targets' stock returns on their announcement day are not related with their prior stock performance, we further control for the actual target price run-up prior to their merger announcements. We estimate the cumulative abnormal stock returns -30 days prior to each merger announcement until day -1.

We also control for firms' market capitalization, price, the number of analysts following, and the presence of blockholders' activity around the merger announcement. Small firms, with low prices and few analysts, typically exhibit relatively larger stock return movements. Blockholders' activity variable is a dummy that takes one for merger deals with relevant activity, and zero otherwise. Blockholders' activity is related with the information

environment available within a merger, and it could potentially influence the magnitude of the stock price reaction of targets on their merger announcements. There may be a strong correlation among these variables, but we include them all in our model. We are not interested *per se* in the sign and the statistical significance of their parameter coefficients, but we want to ensure that firm characteristics that may drive targets' stock returns are not behind the relation.

We also add some merger deal characteristics that are most commonly linked with the stock announcement effect of bidders (e.g., Asquith et al., 1983; Travlos, 1987; Sudarsanam and Mahate, 2003) for further assurance. In particular, we add a dummy for merger deals with more than one bidder, for tender merger deals, for only stock payment deals, for only cash payment deals, for hostile merger deals, for pooling of interest method, and for merger deals when target and bidding firms do not share the first two SIC industry digits.

Finally, we add three-day lagged abnormal target stock returns to further ensure that the relation is in excess of normal variation in their stock returns. We add fixed effects per year, per day of the week, and per month in order to control for potential time variations. For example, some literature (e.g., Patell and Wolfson, 1982; Penman, 1987; Damodaran, 1989; Louis and Sun, 2010) suggests that investors underreact to information announced on Fridays because of their low attention. By contrast, investors' attention is high for Monday announcements. We estimate OLS regressions with Petersen's (2009) clustered standard errors on each day of the week across the study.

Table 2 presents the descriptive statistics of the variables used in this study. As expected, targets experience significant return reactions to their merger announcements (e.g., Jarrell and Poulsen, 1989; Pound and Zeckhauser, 1990; King, 2009). We find that the average abnormal stock returns for targets on their merger announcement are 11.02%. These strong stock returns motivate the study to focus on targets, as discussed in the introduction. There are also evidence of strong increases in cumulative target firms' stock returns prior to their merger

announcements in the interval period (-30, -1 where 0 is the merger announcement day), 4.19%. This result confirms evidence from the target price run up literature (e.g., Jarrell and Poulsen, 1989; Pound and Zeckhauser, 1990; King, 2009) of leak to information prior to relevant public announcements.

[Please insert Table 2 around here]

3. Empirical findings

3.1 Investor sleepiness and targets' abnormal stock returns

We explore in this section the abnormal stock returns of target firms upon their merger announcements on Mondays following daylight saving time changes versus other days. The dependent variable is the abnormal stock returns of target firms, and the main independent variable is the clock change dummy variable. We control for a number of variables as discussed in the methodology section. We expect that investors interpret new information differently when experiencing imbalances on their circadian cycle. Investors who face discrepancy in their sleep patterns have relatively more extreme mood swings and it is thus more likely to overreact to available information. Such investors may then make the target firms that normally experience gains on their merger announcements to even more pronounced profits.

Table 3 presents results with the addition of seasonality dummies and the lagged target stock returns at column (1), with the further addition of firm characteristics at column (2), and with the usage of all control variables at column (3). We undertake this analysis with the gradual inclusion of additional control variables in order to explore the sensitivity of our results to the variables used. We find that target firms experience 2.66% stronger abnormal stock returns on Mondays following clock changes in relation to other target firms after controlling for the full list of the control variables used. This relation is significant at the 1% level and the

magnitude of this difference is economically significant. There are only slight differences in the magnitude of the parameter coefficient for clock change with the addition of control variables highlighting that the relation is unlikely to be driven by firm or merger characteristics.

As expected, we also find that targets experience a lower magnitude stock price reaction to their merger announcements when a rumor is published prior to the announcement and when significant run up was experienced prior to each merger announcement. These results are in line with those shown in the target price run-ups literature (e.g., Jarrell and Poulsen, 1989; Pound and Zeckhauser, 1990; King, 2009). There are also evidence that targets experience more pronounced stock returns on cash-financed merger deals and on hostile/tender merger deals, while they experience lower abnormal stock returns on the announcement of stock merger deals. Once again these results are in line to an extent with evidence available from the merger literature (e.g., Asquith et al., 1983; Travlos, 1987; Sudarsanam and Mahate, 2003). Some of our remaining control variables fail to indicate significance, which is perhaps due to multicollinearity, such as between market capitalization and the number of analysts following a firm. As discussed earlier, we are happy to accept a level of multicollinearity on these variables for the purposes of this study.

[Please insert Table 3 around here]

3.2 Robustness tests

We here explore the robustness on the relation between clock changes and targets' abnormal stock returns. We include all the control variables, but we do not tabulate them for space considerations. Table 4 shows the empirical results. Column (1) first explores the relation when comparing abnormal target stock returns following daylight saving time in relation to other Mondays. Although we added day of the week fixed effects in earlier estimations, this test

intends to offer further validation that our results are present within only Mondays' merger announcements. Although the number of available observations is significantly reduced, we still find that the relevant parameter coefficient remains significantly positive.

[Please insert Table 4 around here]

Column (2) shows results for only merger deals with 100% acquisition. We find that the parameter coefficient in clock change remains significantly positive within this subset. Column (3) reports results without winsorizing the abnormal stock returns of target firms on their merger announcement day. We previously winsorized relevant abnormal stock returns at the top/bottom 1%, and we explore here whether this decision would influence the relation. Once again, we find that the parameter coefficient of clock change remains significantly positive when no winsorization occurs.

Column (4) estimates the regression within the sub-sample of target firms with positive abnormal trading volume. SDC Thomson OneBanker only offers the day of merger announcements, without specifying the timing of these announcements. As an example, some merger announcements could have taken place relatively late in the day or even after the close of the stock market; thus, investors may not have time to react to available information. We estimate the abnormal trading volume for each firm on the merger announcement day in excess of the normal trading volume that takes place in the interval period of -100 to -31 days prior to each merger announcement. We estimate the main relation only within target firms that experienced positive abnormal trading volume on the day of their merger announcements. These are the merger deals that are most likely announced relatively early in the day. We find that the parameter coefficient of clock changes remains significantly positive within this sub-sample.

Column (5) follows a matching procedure as discussed by Abadie et al. (2004) in order to further test whether firm characteristics drive our results. We use LnMV and all merger characteristics used in this study to identify matching firms while we specify a one-to-one firm match. We use the Mahalanobis metric matching (Mahalanobis, 1936) for relevant matching firm identification, which is widely used in recent studies in finance (e.g., Kritzman and Li, 2010). The advantage of the relevant distance metric is that matching firms are selected automatically by the developed algorithm, which minimizes the distance per firm in our sample per matching criterion. Once again, we find that firm characteristics do not drive our relation with the use of this matching analysis. If anything, the difference in abnormal stock returns increases with the use of matched sample analysis (6.39%).

Column (6) follows a GARCH-style analysis and presents results from the mean equation. We estimate GARCH(1,1) in line with Bollerslev (1986). In line with our previous findings, we find that the parameter coefficient on the clock change remains significantly positive at the 1% level with the use of maximum likelihood estimations. The magnitude of the relation is not affected by the model followed.

Finally at column (7), we identify 106 countries that have never followed daylight saving time changes.[5] This offers an ideal setting to undertake a placebo test. Once again we use daylight saving time changes in the US as the main independent variable. The main dependent variable is the abnormal stock returns of global target firms on their merger announcement. We find that the parameter coefficient of clock change is economically and statistically insignificant. When domestic investors experience no disturbances of their circadian cycles, the relation disappears.

[5] https://en.wikipedia.org/wiki/Daylight_saving_time_by_country

3.3 Investor sleepiness and the variance of targets' stock returns

We further estimate the relation between investor sleepiness and the variance of targets' abnormal stock returns. Berument et al. (2010) find no relation between daylight saving time changes and stock market volatility. As discussed in the introduction, we expect that investors face more extreme mood swings and thus likely to generate more extreme stock returns when they face imbalances in their circadian cycle. We therefore expect a positive relation between daylight saving time changes and targets' stock return volatility.

We first estimate the absolute and the squared abnormal stock returns of target firms on their merger announcement day. In these tests we do not winsorize targets' abnormal stock returns, while we use all control variables as previously shown in column 3 of Table 3. As reported in columns (1) and (2) of Table 5 we find that the parameter coefficient on the clock change is significantly positive at the 1% level showing that targets' stock returns are more pronounced on Mondays after daylight saving time changes in relation to other days. Targets for example experience 6.44% higher absolute stock returns on Mondays after daylight saving time changes in relation to other days. The magnitude of this difference is economically significant. Unlike Berument et al. (2010), we find that the context of target firms used by this study makes the relation empirically valid.

[Please insert Table 5 around here]

We further estimate GARCH(1,1) as follows: $r_{it} = \mu_0 + \mu_{DS} DS_t + control\ variables + \varepsilon_{it}$, $\varepsilon_{it} \sim N(0, h_t)$ and the conditional variance of the residual ε_{it} is modelled as $h_t = a_0 + a_{DS} DS_t + \beta h_{t-1} + \gamma e_{t-1}^2$. r_{it} is the abnormal stock return of target firm *i* on the merger announcement day. In line with above result, we find that the parameter coefficient on the clock change (a_{DS}) is significantly positive in the variance equation indicating that targets experience more volatile abnormal stock returns on Mondays after

daylight saving time changes in relation to other days. We do not though tabulate relevant results since we find that the parameter coefficient of the constant (a_0) is significantly negative which violates the model's assumption. Variance cannot be negative (e.g., Nelson and Cao, 1992). As shown in column (3), we instead tabulate results that arrive from using the Exponential GARCH estimation (Nelson, 1991). This model is expressed in the log of h_t as $\ln(h_t) = a_0 + a_{DS}DS_t + \beta\ln(h_{t-1}) + \gamma\frac{e_{t-1}}{\sqrt{h_{t-1}}} + \theta[\frac{|e_{t-1}|}{\sqrt{h_{t-1}}} - \sqrt{\frac{2}{\pi}}]$ (Brooks, 2005) and so the conditional variance equation is always positive regardless of the sign of the parameter coefficients. Once again, we find that the parameter coefficient on the clock change is significantly positive.

4. Conclusion

We use firms targeted for acquisition as the context of our study in order to contribute to the research on daylight saving time change anomaly. We find evidence indicating that investor decisions may vary due to very modest imbalances of their circadian cycle, as long as the relation is tested within an extreme stock return context such as that of the merger announcement of target firms. We report that targets exhibit more pronounced positive stock returns on Mondays following daylight saving time changes in relation to other mergers. Investors tend to exhibit more pronounced mood swings when experiencing sleep disturbances (e.g., Womack et al., 2013). Our evidence seems to indicate that investors overreact to available information when facing disturbances to their circadian cycles.

Our results offer a policy recommendation by showing that daylight saving time changes are not helpful for financial markets. There has been an ongoing debate on the usefulness of following daylight saving time changes in the modern world. A number of jurisdictions in the US have actually envisaged banning daylight saving time changes

altogether. As an example, Rusty Glover, a Republican state senator from Mobile, Alabama, stated, "I would be extremely happy to not go home in the dark… and I think we would see a little more productivity, too."[6] The European Union also recently took the decision to proceed with abolishing daylight saving time changes. This decision is not compulsory but a suggestion for member states, where each needs to decide by April 2019 whether or not to follow. The last compulsory change across all member states within the European Union is on 31 March 2019.[7]

Our results also offer some insight into the debate over whether there should be organizational changes regarding sleep provisions, as deliberated by Walker (2017). Aetna Inc. offers bonuses for employees that manage to sleep well consistently, while Nike Inc. and Google Inc. offer flexibility in employees' work schedules to match sleep preferences or patterns. Goldman Sachs Inc. also offers "sleep hygiene" courses, and an increasing number of firms allow napping while at work (e.g., Bradshaw, 1999). High-grade lighting has also been installed in some offices in order to help employees better regulate their circadian rhythms. Still, very little, within very few firms, has been undertaken considering the effects of sleep cycles on human decisions. Further provisions are thus required for investment firms that would like their fund managers to face less extreme mood swings due to sleep imbalances while investing.

[6] https://www.washingtontimes.com/news/2018/apr/2/daylight-saving-time-should-be-eliminated-say-offi/

[7] https://www.lvm.fi/en/-/commission-proposes-to-end-seasonal-time-changes-982747

References

Abadie, A., Drukker, M., Herr, J., Imbens, G., 2004. Implementing matching estimators for average treatment effects in Stata. Stata Journal 4, 290-311.

Achermann, P., 2004. The two-process model of sleep regulation revisited. Aviation Space and Environmental Medicine 75, 37-43.

Agrawal, A., Nasser, T., 2012. Insider trading in takeover targets. Journal of Corporate Finance 18, 598-625.

Alhola, P., Polo-Kantola, P., 2007. Sleep deprivation: Impact on cognitive performance. Neuropsychiatric Disease and Treatment 3, 553-567.

Asquith, P., Bruner, F., Mullins, D., 1983. The gains to bidding firms from merger. Journal of Financial Economics 11, 121-139.

Banks, S., Dinges, D., 2007. Behavioral and physiological consequences of sleep restriction. Journal of Clinical Sleep Medicine 3, 519-528.

Berument, H., Dogan, N., Onar, B., 2010. Effects of daylight saving time changes on stock market volatility. Psychological Reports 106, 632-640.

Berument, M., Dogan, N., 2011. Effects of daylight saving time changes on stock market volatility: A reply. Psychological Reports 109, 863-878.

Bollerslev, T., 1986. Generalized autoregressive conditional heteroscedasticity. Journal of Econometrics 31, 307-327.

Bradshaw, D., 1999. Why it is always best to be caught napping. Financial Times, p. 11.

Brooks, C., 2005. Introductory econometrics for finance. Cambridge University Press, Cambridge, United Kingdom.

Cho, K., Barnes, C., Guanara, C., 2017. Sleepy punishers are harsh punishers: Daylight saving time and legal sentences. Psychological Science 28, 242-247.

Damodaran, A., 1989. The weekend effect in information releases: A study of earnings and dividend announcements. Review of Financial Studies 2, 607-623.

Dinges, D., 1995. An overview of sleepiness and accidents. Journal of Sleep Research 4, 4-14.

French, K., 1980. Stock returns and the weekend effect. Journal of Financial Economics 8, 55-69.

Gaure, S., 2010. OLS with multiple high dimensional category dummies. Memorandum 14/2010, Oslo University.

Gregory-Allen, R., Jacobsen, B., Marquering, W., 2010. The daylight saving time anomaly in stock returns: Fact or fiction? Journal of Financial Research 33, 403-427.

Guimaraes, P., Portugal, P., 2010. A simple feasible alternative procedure to estimate models with high-dimensional fixed effects. Stata Journal 10, 628-649.

Guiso, L., Sapienza, P., Zingales, L., 2018. Time varying risk aversion. Journal of Financial Economics 128, 403-421.

Jarrell, G., Poulsen, A., 1989. Stock trading before the announcement of tender offers: Insider trading or market anticipation. Journal of Law Economics and Organizations 5, 224-248.

Kamstra, M., Kramer, L., Levi, M., 2000. Losing sleep at the market: The daylight saving anomaly. American Economic Review 90, 1005-1011.

Kamstra, M., Kramer, L., Levi, M., 2002. Losing sleep at the market: The daylight saving anomaly: Reply. American Economic Review 92, 1257-1263.

Kamstra, M., Kramer, L., Levi, M., 2010. Effects of daylight-saving time changes on stock market volatility: A comment. Psychological Reports 107, 877-887.

Kamstra, M., Kramer, L., Levi, M., 2013. Effects of daylight-saving time changes on stock market returns and stock market volatility: Rebuttal. Psychological Reports 112, 89-99.

King, M., 2009. Prebid run-ups ahead of Canadian takeovers: How big is the problem? Financial Management 38, 699-726.

Kritzman, M. and Li, Y., 2010. Skulls, financial turbulence, and risk management. Financial Analysts Journal 66, 30-41.

Louis, H., Sun, A., 2010. Investor inattention and the market reaction to merger announcements. Management Science, 56, 1781-1793.

Mahalanobis, P., 1936. On the generalised distance in statistics. Proceedings of the National Institute of Sciences of India 2, 49-55.

Moeller, S., Schlingemann, F., Stulz, R., 2004. Firm size and the gains from acquisitions. Journal of Financial Economics 73, 201-228.

Nelson, D., 1991. Conditional heteroscedasticity in asset returns: A new approach. Econometrica 59, 347-370.

Nelson, D., Cao, C., 1992. Inequality constraints in the univariate GARCH model. Journal of Business & Economic Statistics 10, 229-235.

Patell, J., Wolfson, M., 1982. Good news, bad news, and the intraday timing of corporate disclosures. Accounting Review 57, 509-527.

Penman, S., 1987. The distribution of earnings news over time and seasonalities in aggregate stock returns. Journal of Financial Economics 18, 199-228.

Petersen, M., 2009. Estimating standard errors in finance panel data sets: Comparing approaches. Review of Financial Studies 22, 435-480.

Pinegar, M., 2002. Losing sleep at the market: Comment. American Economic Review 92, 1251-1256.

Pound, J., Zeckhauser, R., 1990. Clearly heard on the street: The effect of takeover rumors on stock prices. Journal of Business 63, 291-308.

Robb, D., Barnes, T., 2018. Accident rates and the impact of daylight saving time transitions. Accident Analysis & Prevention 111, 193-201.

Schwert, G., 1989. Why does stock market volatility change over time? Journal of Finance 44, 1115-1153.

Smith, A., 2016. Spring forward at your own risk: Daylight saving time and fatal vehicle crashes. American Economic Journal: Applied Economics 8, 65-91.

Sudarsanam, S., Mahate, A., 2003. Glamour acquirers, method of payment and post-acquisition performance: the U.K. evidence. Journal of Business Finance & Accounting 30, 299-341.

Travlos, N., 1987. Corporate takeover bids, methods of payment, and bidding firms stock returns. Journal of Finance 42, 943-963.

Walker, M., 2017. Why we sleep. Penguin Books.

Womack, S., Hook, J., Reyna, S., Ramos, M., 2013. Sleep loss and risk-taking behavior: A review of the literature. Behavioral Sleep Medicine 11, 343-359.

Table 1

Abnormal stock returns of target firms per day of the week.

This table explores the abnormal stock returns of target firms on their merger announcement day in relation to the day of the week the merger announcements occur. P-values are shown in parentheses. *** indicates statistical significance at the one percent level.

		Average	Median
(1)	Weekend & Monday	11.98%	7.02%
(2)	Tuesday	10.81%	4.63%
(3)	Wednesday	10.51%	3.81%
(4)	Thursday	10.90%	4.92%
(5)	Friday	9.84%	2.81%
(1) vs (2), (3), (4) & (5)		1.41%***	
		(0.006)	

Table 2

Descriptive statistics.

This table explores the descriptive statistics of target firms used in the sample. For discussion of the variables used, please study the data section.

	Average	Median	Minimum	Maximum	N
Abnormal stock returns of target firms on their merger announcement day	11.02%	5.05%	-31.77%	79.29%	5713
Clock change (Dummy)	0.02	0.00	0.00	1.00	5713
Rumor (Dummy)	0.04	0.00	0.00	1.00	5713
Run ups	4.19%	3.18%	-75.58%	68.12%	5713
LnMV	4.89	4.85	0.00	12.24	5713
LnPrice	2.60	2.81	0.00	8.40	5713
Ln#Analysts	0.95	0.69	0.00	3.66	5713
Blockholders' activity (Dummy)	0.00	0.00	0.00	1.00	5713
Tender (Dummy)	0.16	0.00	0.00	1.00	5713
More than one bidder (Dummy)	0.03	0.00	0.00	1.00	5713
Cash deal (Dummy)	0.27	0.00	0.00	1.00	5713
Stock deal (Dummy)	0.36	0.00	0.00	1.00	5713
Hostile (Dummy)	0.01	0.00	0.00	1.00	5713
Different industry (Dummy)	0.32	0.00	0.00	1.00	5713
Pooling of interest method (Dummy)	0.15	0.00	0.00	1.00	5713

Table 3

Investor sleepiness and the abnormal stock returns of targets.

This table explores the relation between targets' abnormal stock returns and clock changes. The dependent variable is the abnormal stock returns of target firms on the merger announcement day, day 0. Our main independent variable is clock change, which is a dummy that takes one for merger deals announced on Mondays or over the weekend following US daylight saving time changes, and zero otherwise. For discussion of the control variables used, please study the data section. P-values are shown in parentheses. *, and *** indicate statistical significance at the ten, and one percent levels, respectively.

	Abnormal stock returns of target firms on their merger announcement day		
	(1)	(2)	(3)
Clock change (Dummy)	0.0220***	0.0269***	0.0266***
	(0.000)	(0.000)	(0.000)
Rumor (Dummy)		-0.0734***	-0.0720***
		(0.005)	(0.005)
Run ups		-0.0512***	-0.0590***
		(0.002)	(0.003)
LnMV		-0.0011	-0.0013
		(0.634)	(0.570)
LnPrice		0.0227***	0.0234***
		(0.000)	(0.000)
Ln#Analysts		0.0009	-0.0007
		(0.847)	(0.880)
Blockholders' activity (Dummy)			0.0653
			(0.134)
Tender (Dummy)			0.0383***
			(0.000)
More than one bidder (Dummy)			-0.0156
			(0.328)
Cash deal (Dummy)			0.0386***
			(0.003)
Stock deal (Dummy)			-0.0113*
			(0.078)
Hostile (Dummy)			0.0204***
			(0.005)
Different industry (Dummy)			0.0149***
			(0.005)
Pooling of interest method (Dummy)			0.0153
			(0.125)
Constant	0.1329***	0.0804***	0.0776***
	(0.000)	(0.001)	(0.001)
Three-day lagged target returns	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
Day of the week fixed effects	Yes	Yes	Yes
Monthly fixed effects	Yes	Yes	Yes
N	5713	5713	5713
R-square Adj	0.0543	0.0745	0.101

Table 4

Robustness tests.

This table explores the robustness of the main relation. The dependent variable is the abnormal stock returns of target firms on the merger announcement day, day 0. Our main independent variable is clock change, which is a dummy that takes one for merger deals announced on Mondays or over the weekend following US daylight saving time changes, and zero otherwise. P-values are shown in parentheses. ** and *** indicate statistical significance at the five and one percent levels, respectively.

	Abnormal stock returns of target firms on their merger announcement day						
	Only for Monday deals	Only 100% merger deals	No winsorization of stock returns	With positive abnormal trading volume	Only matching firms	GARCH(1,1) Mean equation	Placebo Non-US targets
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Clock change (Dummy)	0.0285***	0.0380***	0.0240***	0.0377***	0.0639**	0.0210***	0.0059
	(0.003)	(0.000)	(0.000)	(0.000)	(0.023)	(0.000)	(0.342)
Constant	-0.0548**	0.0570***	0.0651**	0.0668**		0.0426***	0.0347
	(0.017)	(0.003)	(0.048)	(0.018)		(0.000)	(0.117)
Prior controls	Yes	Yes	Yes	Yes	No	Yes	Yes
Matching ratio					1-1		
N	1695	5238	5713	4785		5713	2415
R-square Adj	0.1511	0.1005	0.0818	0.1066			0.0446
Log-L						1957	

Table 5

Investor sleepiness and the variance of targets' stock returns.

This table explores the relation between investor sleepiness and the variance of targets' abnormal stock returns on their merger announcement day, day 0. Our main independent variable is clock change, which is a dummy that takes one for merger deals announced on Mondays or over the weekend following US daylight saving time changes, and zero otherwise. For discussion of the control variables used, please study the data section. P-values are shown in parentheses. *, **, and *** indicate statistical significance at the ten, five, and one percent levels, respectively.

	Absolute abnormal stock returns	Squared abnormal stock returns	Variance equation Abnormal stock returns - EGARCH(1,1)	
	(1)	(2)		(3)
Clock change (Dummy)	0.0644***	0.0773***	Clock change (Dummy)	0.8793***
	(0.000)	(0.000)		(0.000)
Rumor (Dummy)	-0.0509***	-0.0096	Constant	-2.6142***
	(0.005)	(0.291)		(0.000)
Run ups	-0.0770***	-0.0607**	L.EARCH	0.1281
	(0.001)	(0.023)		(0.155)
LnMV	-0.0054**	-0.0148***	L.EARCH_A	0.1432*
	(0.012)	(0.002)		(0.073)
LnPrice	0.0023	-0.0083	L.EGARCH	0.1548
	(0.588)	(0.346)		(0.325)
			Previously used control variables in the mean equation	Yes
Ln#Analysts	0.0023	0.0058		
	(0.443)	(0.111)	N	5713
Blockholders' activity (Dummy)	0.0433	0.011	Log-L	749
	(0.300)	(0.571)		
Tender (Dummy)	0.0358***	0.0283***		
	(0.004)	(0.006)		
More than one bidder (Dummy)	-0.0184	-0.0202**		
	(0.104)	(0.041)		
Cash deal (Dummy)	0.0274**	-0.0077		
	(0.016)	(0.626)		
Stock deal (Dummy)	-0.0152***	-0.0307***		
	(0.004)	(0.009)		
Hostile (Dummy)	0.0276***	0.0203*		
	(0.001)	(0.077)		
Different industry (Dummy)	0.0097	0.0022		
	(0.199)	(0.838)		
Pooling of interest method (Dummy)	0.0228**	0.0247**		
	(0.031)	(0.042)		
Constant	0.1246***	0.1178**		
	(0.000)	(0.016)		
Three-day lagged corresponding returns	Yes	Yes		
Year fixed effects	Yes	Yes		
Day of the week fixed effects	Yes	Yes		
Monthly fixed effects	Yes	Yes		
N	5713	5713		
R-square Adj	0.0769	0.0298		